PB-240 347

OTTER LAKE, CAYUGA COUNTY, NEW YORK

Pacific Northwest Environmental
Research Laboratory

Prepared for:

National Environmental Research Center
New York State Department of Environmental
Conservation
New York National Guard

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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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REPORT

ON

OTTER LAKE

CAYUGA COUNTY

NEW YORK

EPA REGION II

WORKING PAPER No. 164

WITH THE COOPERATION OF THE

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

AND THE

NEW YORK NATIONAL GUARD

DECEMBER, 1974

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the New York Department of Environmental Conservation for professional involvement and to the New York National Guard for conducting the tributary sampling phase of the Survey.

Henry L. Diamond, Commissioner of the New York Department of Environmental Conservation, and Leo J. Hetling, Director, and Italo G. Carcich, Senior Sanitary Engineer, Environmental Quality Research, Department of Environmental Conservation, provided invaluable lake documentation and counsel during the Survey.

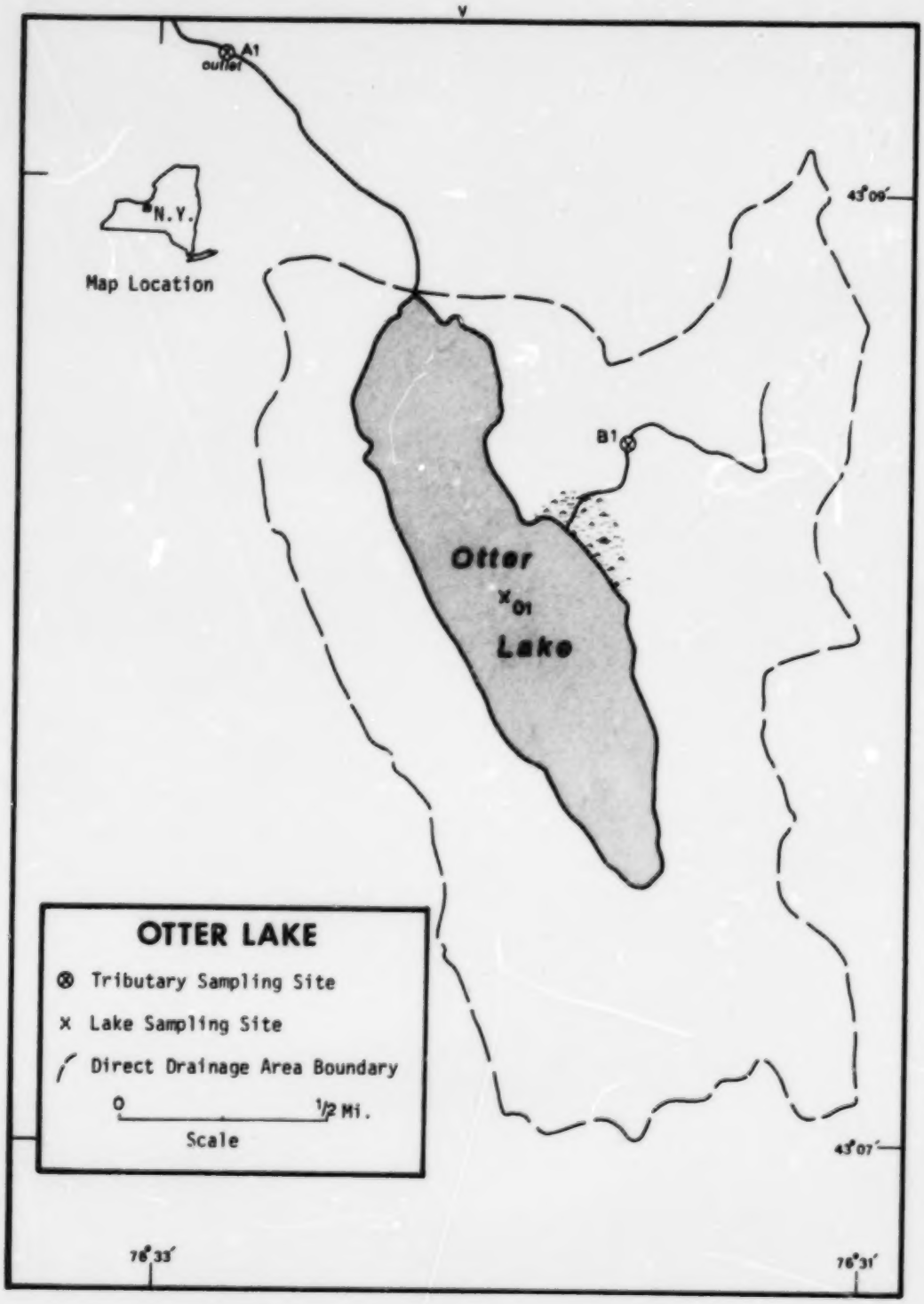
Major General John C. Baker, the Adjutant General of New York, and Project Officer Lieutenant Colonel Fred Peters, who directed the volunteer efforts of the New York National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF NEW YORK

LAKE NAME	COUNTY
Allegheny Reservoir	Cattaraugas, NY; McLean, Warren, PA
Black	St. Lawrence
Canadaigua	Ontario
Cannonsville	Delaware
Carry Falls	St. Lawrence
Cassadaga	Chautauqua
Cayuga	Seneca, Tompkins
Champlain	Clinton, Essex, NY; Addison, Chittenden, Franklin, VT
Chautauqua	Chautauqua
Conesus	Livingston
Cross	Cayuga, Onondaga
Goodyear	Otsego
Huntington	Sullivan
Keuka	Ontario
Long	Hamilton
Lower St. Regis	Franklin
Otter	Cayuga
Owasco	Cayuga
Raquette Pond	Franklin
Round	Saratoga
Sacandaga Res.	Fulton, Saratoga
Saratoga	Saratoga
Schroon	Essex, Warren
Seneca	Seneca, Schyler, Yates
Swan	Sullivan
Swinging Bridge Res.	Sullivan


A1
outlet
N.Y.
Map Location
43°09'
B1
Otter
01
Lake
OTTER LAKE
Tributary Sampling Site
Lake Sampling Site
Direct Drainage Area Boundary
0
1/2 Mi.
Scale
43°07'
76°33'
76°31'

OTTER LAKE

STORET NO. 3625

I. CONCLUSIONS

A. Trophic Condition:

Survey data show that Otter Lake is eutrophic. Of the 26 New York lakes sampled in the fall of 1972, when essentially all were well-mixed, 18 had less mean total phosphorus, 11 had less mean dissolved phosphorus, and 10 had less mean inorganic nitrogen. For all New York data, 20 lakes had less mean chlorophyll a, and 24 had greater mean Secchi disc transparency.

Survey limnologists noted turbid water on all sampling dates with moderate algae blooms in progress during the July and October sampling periods.

B. Rate-Limiting Nutrient:

The results of the algal assay indicate phosphorus limitation at the time the sample was collected. The lake data also indicate phosphorus limitation at all sampling times; i.e., N/P ratios were greater than 20/1, and phosphorus limitation would be expected.

C. Nutrient Controllability:

During the sampling year, there was an apparent loss of phosphorus from Otter Lake; i.e., more phosphorus was measured leaving the lake than can be accounted for by all measured and estimated

inputs. The cause of the imbalance is not known, but it is unlikely that phosphorus "wash-out" occurred or that a direct-discharge point source was overlooked. Considering the rather small phosphorus loads involved (see page 9), the imbalance could have been due to the accuracy of the flow estimates provided by the U.S. Geological Survey (see page 3).

Considering the phosphorus load leaving the lake to be at least equivalent to the input loads, it is calculated that Otter Lake received a total phosphorus load at a rate approximately that proposed by Vollenweider (in press) as "permissible"; i.e., an oligotrophic rate (see page 11). However, in view of the eutrophic condition of the lake, the calculated loading rate is likely in error.

There are no known point sources impacting the lake, and the entire phosphorus load was contributed by non-point sources.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry:

1. Surface area: 282 acres†:
2. Mean depth: unknown
3. Maximum depth: unknown
4. Volume: unknown

B. Tributary and Outlet:
(See Appendix A for flow data)

1. Tributaries -

Name	Drainage area*	Mean flow*
Unnamed Creek (B-1)	0.4 mi^2	0.5 cfs
Minor tributaries & immediate drainage -	2.1 mi^2	3.3 cfs
Totals	2.5 mi^2	3.8 cfs

2. Outlet -

Unnamed Creek (A-1)	2.9 mi^2**	3.8 cfs

C. Precipitation:

1. Year of sampling***: 52.8 inches.
2. Mean annual: 37.6 inches.

---

† Greeson and Robison, 1970.
* Drainage areas are accurate within ±5%, except for small basins (±10%); mean daily flows are accurate within ±5 to 25%; and normalized mean monthly flows are accurate within ±15%.
** Includes area of lake.
*** See Working Paper No. 1, "Survey Methods".

III. LAKE WATER QUALITY SUMMARY

Otter Lake was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two depths at a single station on the lake (see map, page v). During each visit, a depth-integrated (near bottom to surface) sample was collected for phytoplankton identification and enumeration; and during the last visit, a five-gallon depth-integrated sample was collected for algal assays. Also each time, a depth-integrated sample was collected for chlorophyll *a* analysis. The maximum depth sampled was 6 feet.

The results obtained are presented in full in Appendix B, and the data for the fall sampling period, when the lake essentially was well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix B.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (10/13/72)		
Temperature (Cent.)	11.2	11.2	11.2	11.2
Dissolved oxygen (mg/l)	10.4	10.4	10.4	10.4
Conductivity (μmhos)	265	268	268	270
pH (units)	8.2	8.2	8.2	8.2
Alkalinity (mg/l)	129	130	130	131
Total P (mg/l)	0.027	0.044	0.044	0.061
Dissolved P (mg/l)	0.009	0.010	0.010	0.012
NO_2 + NO_3 (mg/l)	0.100	0.105	0.105	0.110
Ammonia (mg/l)	0.130	0.130	0.130	0.130
		ALL VALUES		
Secchi disc (inches)	24	45	41	70

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
05/17/72	1. Fragilaria	904
	2. Dinobryon	754
	3. Lyngbya	497
	4. Cyclotella	482
	5. Flagellates	113
	Other genera	468
	Total	3,218
07/24/72	1. Lyngbya	14,130
	2. Polycystis	6,812
	3. Fragilaria	3,333
	4. Chroococcus	978
	5. Melosira	580
	Other genera	1,377
	Total	27,210
10/13/72	1. Lyngbya	16,616
	2. Synedra	2,632
	3. Chroococcus	2,481
	4. Flagellates	1,278
	5. Oscillatoria	1,278
	Other genera	2,783
	Total	27,068

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (µg/l)
05/17/72	01	4.6
07/24/72	01	15.6
10/13/72	01	19.8

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.007	0.125	1.1
0.010 P	0.017	0.125	3.1
0.020 P	0.027	0.125	3.8
0.050 P	0.057	0.125	4.2
0.050 P + 5.0 N	0.057	5.125	18.5
0.050 P + 10.0 N	0.057	10.125	18.4
10.0 N	0.007	10.125	0.3

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Otter Lake was moderate at the time the algal assay sample was collected.

The addition of orthophosphorus (to about 20 µg/l) produced significant increases in the assay yield. However, the addition of only nitrogen did not produce a significant response in yield as compared to the control yield, thus indicating phosphorus limitation at the time the sample was collected.

The lake data also indicate phosphorus limitation at all sampling times; N/P ratios were greater than 20/1, and phosphorus limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, the New York National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of March and April when two samples were collected. Sampling was begun in November, 1972, and was completed in June, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the New York District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in lbs/mi^2/year, at station B-1 and multiplying the means by the ZZ area in mi^2.

There are no known point sources affecting Otter Lake.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

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* See Working Paper No. 1.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Unnamed Creek (B-1)	20	11.1
b. Minor tributaries & immediate drainage (non-point load) -	110	66.7
c. Known municipal - None	-	-
d. Septic tanks - Unknown	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	40	22.2
Total	170	100.0

2. Outputs -

Lake outlet - Unnamed Creek (A-1) 390

3. Net annual P loss - 210 pounds

* See Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	lbs N/ yr	% of total
a. Tributaries (non-point load) -		
Unnamed Creek (B-1)	2,180	12.6
b. Minor tributaries & immediate drainage (non-point load) -	11,440	71.7
c. Known municipal - None	-	-
d. Septic tanks - Unknown	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	2,720	15.7
Total	16,340	100.0

2. Outputs -

Lake outlet - Unnamed Creek (A-1) 14,110

3. Net annual N accumulation - 2,230 pounds

* See Working Paper No. 1.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	lbs P/mi^2/yr	lbs N/mi^2/yr
Unnamed Creek (B-1)	50	5,450

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (in press). Essentially, his "dangerous" rate is the rate at which the receiving water would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

	Total Phosphorus		Total Nitrogen	
Units	Total	Accumulated	Total	Accumulated
lbs/acre/yr	1.4	loss	57.9	7.9
grams/m^2/yr	0.16	-	6.5	0.9

Vollenweider loading rates for phosphorus (g/m^2/yr) based on the surface area and mean outflow of Otter Lake:

"Dangerous" (eutrophic rate)	0.34
"Permissible" (oligotrophic rate)	0.17

V. LITERATURE REVIEWED

Greeson, Phillip E., and F. Luman Robison, 1970. Characteristics of New York lakes. Part 1 - Gazateer of lakes, ponds, and reservoirs. Bull. 68, U.S. Dept. Int. and NY Dept. of Env. Cons., Albany.

Vollenweider, Richard A. (in press). Input-output models. Schweiz. A. Hydrol.

VII. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR NEW YORK 11/26/74

LAKE CODE 3625 OTTER LAKE

TOTAL DRAINAGE AREA OF LAKE 2.91

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3625A1	2.91	4.00	5.90	12.00	9.20	3.60	1.60	0.70	0.30	0.50	1.00	3.10	3.90	3.80
3625B1	0.37	0.50	0.70	1.40	1.10	0.40	0.20	0.10	0.10	0.10	0.10	0.40	0.50	0.46
3625ZZ	2.54	3.50	5.20	11.00	8.10	3.20	1.40	0.60	0.20	0.40	0.90	2.70	3.40	3.37

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 2.91
SUM OF SUB-DRAINAGE AREAS = 2.91

TOTAL FLOW IN = 46.20
TOTAL FLOW OUT = 45.80

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3625A1	11	72	8.00	4	5.10				
	12	72	12.00	2	8.60				
	2	73	8.80	3	32.00				
	3	73	13.00	3	4.00	31	3.60		
	4	73	12.00	13	6.50	29	9.20		
	5	73	4.80	31	3.20				
	6	73	2.20	9	2.10				
	7	73	0.60	23	0.30				
	8	73	0.30	25	0.30				
	9	73	0.20	15	0.10				
3625B1	11	72	1.00	4	0.60				
	12	72	1.60	2	1.10				
	2	73	1.00	3	3.90				
	3	73	1.50	3	0.50	31	0.40		
	4	73	1.40	13	0.80	29	1.00		
	5	73	0.50	31	0.40				
	6	73	0.30	9	0.30				
	7	73	0.10	23	0.0				
	8	73	0.10	25	0.0				
	9	73	0.0	15	0.0				
3625ZZ	11	72	6.90						
	12	72	11.00						
	1	73	9.20						
	2	73	7.70						
	3	73	12.00						
	4	73	11.00						
	5	73	4.30						
	6	73	1.90						
	7	73	0.50						
	8	73	0.20						
	9	73	0.20						

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/11/26

362501
43 08 24.0 076 32 02.0
OTTER LAKE
36 NEW YORK

11EPALES
3

2111202
0010 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/05/17	18 25	0000	17.7	9.3	70	340	8.00	118	0.340	0.310	0.025	0.011
	18 25	0006	17.7	7.8		260	8.10	122	0.340	0.350	0.233	0.012
72/07/24	17 50	0000			41	280	8.60	115	0.100	0.090	0.043	0.008
72/10/13	15 35	0000			24	270	8.20	131	0.110	0.130	0.027	0.009
	15 35	0004	11.2	10.4		265	8.20	129	0.100	0.130	0.061	0.012

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/05/17	18 25	0000	4.6J
72/07/24	17 50	0000	15.6J
72/10/13	15 35	0000	19.8J

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY DATA

STORET RETRIEVAL DATE 74/11/26

3625A1 LS3625A1
43 09 30.0 076 33 00.0
UNNAMED CREEK
36 7.5 CATO
0/OTTER LAKE
SHORT CUT ROAD 1 MI SW OF MERIDIAN
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/11/04	09 45		0.195	0.660	0.094	0.066	0.090
72/12/02	14 15		0.490	0.520	0.032	0.010	0.030
73/02/03	12 28		0.420	0.820	0.069	0.008	0.025
73/03/03	14 00		0.870	3.360	0.220	0.008	0.030
73/03/31	15 50		0.154	1.890	0.066	0.009	0.055
73/04/13	15 35		0.100	0.840	0.042	0.005K	0.025
73/04/29	12 15		0.034	0.810	0.138	0.022	0.045
73/05/31	19 30		0.060	1.980	0.074	0.033	0.050
73/06/09	12 10		0.013	3.200	0.115	0.080	0.095

K VALUE KNOWN TO BE
LESS THAN INDICATED

31

STORET RETRIEVAL DATE 74/11/26

362581 LS362581
43 08 30.0 076 31 30.0
UNNAMED CREEK
36 7.5 CATO
T/OTTER LAKE
AT BONTA BRIDGE ROAD BRIDGE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/11/04	09 20		2.400	1.000	0.058	0.008	0.018
72/12/02	14 30		1.660	0.260	0.010	0.005K	0.014
73/02/03	12 20		1.960	0.400	0.039	0.011	0.050
73/03/03	10 50		2.300	0.390	0.031	0.008	0.050
	14 00		2.040	0.580	0.036	0.017	0.017
73/03/31	15 45		1.000	0.440	0.027	0.005K	0.015
73/04/13	15 23		1.140	0.790	0.033	0.006	0.010
73/05/31	19 40		1.000	1.260	0.030	0.005K	0.010
73/06/09	12 00		1.720	0.380	0.033	0.020	0.020

K VALUE KNOWN TO BE
LESS THAN INDICATED